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Floristic Diversity along an Altitudinal Gradients in Hango Valley of Cold Desert in District Kinnaur, Himachal Pradesh

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ABSTRACT: Cold deserts-a unique ecosystem in itself, lies in the lap of Himalayas, which is quite fragile and sensitive. The biotic pressure on this particular ecosystem as exerted by increasing human and cattle population coupled with over exploitation has resulted in its ecological degradation. Accordingly, a study was conducted to understand the floristic diversity along an altitudinal gradient with elevations varying from 3400m to 5000m above msl in Hango valley falling in cold desert area of district Kinnaur, Himachal Pradesh. Total number of plant species was 130 belonging to 41 families and 101 genera. The dominant families were Asteraceae, Polygonaceae, Ranunculaceae, Lamiaceae and Umbelliferae. Number of tree species at 3400-3800m elevation was 3 with the dominance of *Salix alba*. The number of shrubs species were 9, 5, 3 and 2 with the dominance of *Rosa webbiana, Cotoneaster microphyllus, Juniperus indica* and *Rhododendron anthopogon* in the elevations of 3400-3800m, 3800-4200m, 4200-4600m and 4600-5000m respectively. The number of herb species were 73, 63, 36 and 30 at 3400-3800m, 3800-4200m, 4200-4600 and 4600-5000m elevation respectively. *Heracleum candicans* was dominant at 3400-3800m elevation and *Bergenia stracheyi* was dominant herbs at 3800-4200m, 4200-4600m and 4600-5000m elevation on the basis of Importance Value Index. The distribution pattern of most the plant species was contiguous in all the altitudinal ranges. Index of diversity for herb species in different elevation ranges was 3.82, 3.51, 3.20 and 3.18. The richness and evenness index was comparatively more in lower altitudinal ranges than higher altitudinal ranges indicating that species are evenly distributed in lower elevations. Index of similarity calculated for shrub and herb species indicating more dissimilarity of species between different altitudes. Out of 62 medicinal plant species recorded from the area, 18 species i.e. *Aconitum violaceum, Arnebia euchroma, Bergenia stracheyi, Dactylorhiza hatagirea, Ephedra gerardiana, Ferula jaschkeana, Hippophae rhamnoides, Hyoscyamus niger, Hyssopus officinalis, Juniperus polycarpos, Meconopsis aculeata, Pleurospermum candollei, Rheum webbianum, Rhodiola heterodonta, Rhododendron anthopogon, Rhododendron campanulatum, Saussurea obvallata* and *Saussurea gossypiphora* fall in the category of threatened plants. The better conservation of natural resources can be done through promotion of community based conservation, *in-situ* conservation through the establishment of nature reserves, *ex-situ* conservation through tissue culture, developing cultivation technologies and nurseries of medicinal plants and conducting of regular training on the procedure of medicinal plants collection and processing among the end users.

Key Words: Floristic diversity, Dominance, Altitudinal gradients, Distribution pattern

INTRODUCTION

The diverse climate and the varied environmental conditions prevailing in Himalayas support diverse habitat and ecosystems with equally diverse life forms. Himalayas are one of the largest and youngest mountain chains in the world and cover roughly 10% of India total land surface. Variations in terms of its size, climate and altitudinal ranges have created environments those are unique and characteristic to this region only. It provides an important habitat to the flora and fauna including 9,000 species of angiosperms and hence, is considered as the hot spot of biodiversity. There are about 3,470 species considered exclusively endemic to the Himalayas. The cold deserts in India occur in Ladakh region of Jammu & Kashmir, Spiti valley of Lahaul and Spiti district and Pooh sub division of Kinnaur district of Himachal Pradesh. The total area under cold deserts in Himachal Pradesh is about 11,000 sq.km., out of which 3,400 sq.km. area is in Kinnaur district. Human pressure on natural ecosystems is intensifying, some being incompatible with survival of certain species of plants. In cold desert areas, continuous removal of plant species for various uses and overgrazing by migratory livestock have resulted in desertification and loss of biodiversity.

If these naturally occurring plant resources are not timely conserved then they may soon become extinct. In cold desert this genetic erosion coupled with soil erosion may retard prospects of future economic development and welfare of the people. The assessment of plant wealth in this harsh cold arid belt may provide a key for its conservation. Keeping these aspects in view, a study was undertaken to know the plant diversity in Hango valley of cold desert in Kinnaur district of Himachal Pradesh.

MATERIALS AND METHODS

The present study was conducted in Hango valley of cold desert area of Pooh sub division of district Kinnaur, Himachal Pradesh during, 2008 at an elevation of 3400m to 5000m. The study site was situated 31°49'35.4" to 31°48'30.2" N latitude and 78° 31'99.8" to 78°33'83.0" E longitudes. The whole area of the valley was divided into four altitudes i.e. 3400-3800m, 3800-4200m, 4200-4600m and 4600-5000m for conducting the phyto-sociological study. Quadrats were laid out in stratified random manner along the altitudinal transects. Quadrats of size 10mx10m, 3mx3m amd 1mx1m laid out randomly for enumerating trees, shrubs and herbs + regeneration respectively. A total of 20, 30 and 40 quadrats for tree, shrub and herb respectively were laid out in each altitudinal gradient. The seedlings were considered as herb while saplings as shrubs. The vegetation data was analysed for density, frequency and abundance according to formulae given by Curtis and McIntosh (1950). The relative values of density, frequency and dominance were summed to get Importance Value Index (IVI) of individual species. The abundance to frequency ratio (A/F) of different species was determined for eliciting the distribution pattern. This ratio indicates regular (<0.025), random (0.025 to 0.050) and contiguous (>0.050) distribution (Curtis and Cottam, 1956). The plant species diversity was calculated by using Shannon-Wiener diversity Index (H) (Shannon-Wiener, 1963).

$$H = - \sum_{i=1}^{S} (Ni/N) \ln (Ni/N)$$

Concentration of dominance (C) was measured by Simpson's Index (Simpson, 1949).

$$C = \sum_{i=1}^{S} (Ni/N)^2$$

Where Ni = importance value of species i and N= total importance value of all the species in both the indices.

Index of similarity and dissimilarity between different altitudes were calculated by using following formula (Misra, 1989).

Index of similarity, S = 2C / A+B

Where A= number of species in community A, B = number of species in community B, C = number of species common to both communities.

Index of dissimilarity = 1-S

Richness Index was estimated as per Margalef (1958) *i .e.* R = S-1/ln N

Evenness Index was calculated as per Hill (1973) *i. e.* E = H/ ln S

Where S = total number of species, N= total number of individuals of all the species, H = Index of diversity.

RESULTS AND DISCUSSION

At elevation of 3400-3800m total number of tree species was 3 (Table 1) with the dominance of *Salix alba* followed by *Populus alba* and *Juniperus polycarpos* in term of density and frequency. For a particular species higher frequency indicates its more frequent distribution at a particular site. The value of abundance was maximum for *Juniperus polycarpos* followed by *Salix alba* and *Populus alba.* Importance Value Index is the most important parameter to understand the community organization in relation to the comparative ability. *Salix alba* recorded highest value of IVI (155.95) followed by *Populus alba* (125.04) and *Juniperus polycarpos* (19.01). The distribution pattern of *Juniperus polycarpos* was contiguous whereas for *Populus alba* and *Salix alba* it was random. The contiguous distribution is the commonest pattern in nature, random distribution is found in very uniform environment. The general preponderance of contiguous distribution in vegetation has been reported by several workers (Kershaw, 1973; Singh and Yadava, 1974; Kunhikannan *et al.*, 1998).

Among the 9 species of shrubs including saplings (Table 2), *Rosa webbiana* was dominant species having maximum density and frequency. This was followed by *Salix alba*, *Astragalus rhizanthus* and *Hippophae rhamnoides* in term of density. The value of abundance was maximum for *Salix alba* followed *Rosa webbiana*, *Ribes alpestre* and *Myricaria germanica*. *Rosa webbiana* recorded highest value IVI (71.17) followed by *Hippophae rhamnoides* (68.56), *Myricaria germanica* (37.98) and *Salix alba* (34.63). The distribution pattern of all the species was contiguous. In case of herbs, total number of species was 73 at 3400-3800 m elevation (Table 3). *Mentha longifolia* was dominant herb followed by *Arenaria festucoides*, *Heracleum candicans* and *Arnebia guttata* in term of density.

Table 1: Distribution of tree species in Hango valley of district Kinnaur at 3400-3800m elevation.

S. No.	Species	Density (ha^{-1})	Frequ-ency(%)	Abun-dance	A/F	IVI
1.	*Juniperus polycarpos* C. Koch	30.00	10.00	3.00	0.300	19.01
2.	*Populus alba* Linn.	165.00	65.00	2.54	0.039	125.04
3.	*Salix alba* Linn.	235.00	90.00	2.61	0.029	155.95

Table 2: Distribution of shrub species in Hango valley of district Kinnaur at 3400-3800m elevation.

S. No.	Species	Density (ha^{-1})	Frequ-ency (%)	Abund-ance	A/F	IVI
1.	*Astralagus rhizanthus* Royle ex. Benth	3370.37	40.00	7.58	0.190	34.50
2.	*Cotoneaster microphyllus* Wall ex. Lindl.	1148.15	16.67	6.20	0.372	19.13
3.	*Hippophae rhamnoides* Linn.	2222.22	33.33	6.00	0.180	68.56
4.	*Juniperus polycarpos* * C. Koch	74.07	3.33	2.00	0.600	2.91
5.	*Lonicera spinosa* Jacq.	1851.85	23.33	7.14	0.306	21.10
6.	*Myricaria germanica* (L.) Desv.	1185.19	13.33	8.00	0.600	37.98
7.	*Ribes alpestre* Wall. ex. Decne	1000.00	10.00	9.00	0.900	10.01
8.	*Rosa webbiana* Wall. ex. Royle	7481.48	63.33	10.63	0.168	71.17
9.	*Salix alba* * Linn.	4185.19	16.67	22.60	1.356	34.63

*Sapling

Table 3: Distribution of herbs species in Hango valley of district Kinnaur at 3400-3800m elevation.

S. No.	Species	Density (m^{-2})	Frequ-ency (%)	Abund-ance	A/F	IVI
1.	*Aconogonum tortuosum* D. Don Hara	0.63	10.00	6.25	0.625	3.21
2.	*Anaphalis triplinervis* (Sims) C. B.Clarke	0.30	10.00	3.00	0.300	1.99
3.	*Anemone obtusiloba* D.Don	0.23	10.00	2.25	0.225	1.67
4.	*Anemone rivularis* Buch- Ham ex. DC.	3.00	20.00	15.00	0.750	10.49
5.	*Arenaria festucoides* Benth	3.33	30.00	11.08	0.369	11.25
6.	*Arnebia euchroma* (Royle ex. Benth) I.M.Johnston	0.30	10.00	3.00	0.300	2.72
7.	*Arnebia guttata* Bunge	1.25	12.50	10.00	0.800	6.20
8.	*Astragalus dracunculus* L. Tarragon	0.85	12.50	6.80	0.544	6.59
9.	*Astragalus rhizanthus* Royle ex. Benth	0.48	12.50	3.80	0.304	4.51
10.	*Bupleurum falcatum* Linn.	0.10	2.50	4.00	1.600	0.63
11.	*Bupleurum tenue* Buch-Ham ex D.Don	0.63	20.00	3.13	0.156	3.78
12.	*Cannabis sativa* L. Hemp	0.10	2.50	4.00	1.600	1.79
13.	*Capparis spinosa* Linn.	0.05	2.50	2.00	0.800	0.44
14.	*Chenopodium album* Linn.	0.20	7.50	2.67	0.356	2.08
15.	*Chenopodium ambrosisoides* Linn.	0.08	2.50	3.00	1.200	0.54
16.	*Chenopodium foliolosum* (Moench) Asch	0.15	7.50	2.00	0.267	1.51

17.	*Aconogonum tortuosum* D. Don Hara	0.63	10.00	6.25	0.625	3.21
18.	*Anaphalis triplinervis* (Sims) C. B.Clarke	0.30	10.00	3.00	0.300	1.99
19.	*Anemone obtusiloba* D.Don	0.23	10.00	2.25	0.225	1.67
20.	*Anemone rivularis* Buch- Ham ex. DC.	3.00	20.00	15.00	0.750	10.49
21.	*Arenaria festucoides* Benth	3.33	30.00	11.08	0.369	11.25
22.	*Arnebia euchroma* (Royle ex. Benth) I.M.Johnston	0.30	10.00	3.00	0.300	2.72
23.	*Arnebia guttata* Bunge	1.25	12.50	10.00	0.800	6.20
24.	*Astragalus dracunculus* L. Tarragon	0.85	12.50	6.80	0.544	6.59
25.	*Astragalus rhizanthus* Royle ex. Benth	0.48	12.50	3.80	0.304	4.51
26.	*Bupleurum falcatum* Linn.	0.10	2.50	4.00	1.600	0.63
27.	*Bupleurum tenue* Buch-Ham ex D.Don	0.63	20.00	3.13	0.156	3.78
28.	*Cannabis sativa* L. Hemp	0.10	2.50	4.00	1.600	1.79
29.	*Capparis spinosa* Linn.	0.05	2.50	2.00	0.800	0.44
30.	*Chenopodium album* Linn.	0.20	7.50	2.67	0.356	2.08
31.	*Chenopodium ambrosisoides* Linn.	0.08	2.50	3.00	1.200	0.54
32.	*Chenopodium foliolosum* (Moench) Asch	0.15	7.50	2.00	0.267	1.51
33.	*Cirsium wallichi* DC.	0.48	27.50	1.73	0.063	6.77
34.	*Clematis orientalis* Linn.	0.18	10.00	1.75	0.175	
35.	*Conyza stricta* Willd.	0.50	20.00	2.50	0.125	3.53
36.	*Corydalis govaniana* Wall.	0.15	7.50	2.00	0.267	2.16
37.	*Cynoglossum furcatum* Wall ex Roxb.	0.93	42.50	2.18	0.051	7.02
38.	*Dactylorhiza hatagirea* D.Don	0.10	2.50	4.00	1.600	0.61
39.	*Echinops cornigerus* DC.	0.28	10.00	2.75	0.275	3.97
40.	*Ephedra gerardiana* Wall. ex. Stapf.	1.20	7.50	16.00	2.133	19.72
41.	*Epilobium hirsutum* Linn.	0.58	12.50	4.60	0.368	3.30
42.	*Epilobium laxum* Royle	0.45	7.50	6.00	0.800	2.02
43.	*Equisetum arvense* Linn.	0.58	7.50	7.67	1.022	2.47
44.	*Eremenus himalaicus* Baker	0.35	12.50	2.80	0.224	3.71
45.	*Erigeron alpines* Linn.	0.28	10.00	2.75	0.275	1.82
46.	*Fagopyrum dibotrys* D.Don Hara	0.53	20.00	2.63	0.131	4.42
47.	*Ferula jaeschkeana* Vatke	0.23	10.00	2.25	0.225	3.15
48.	*Galium aparine* Linn.	0.43	10.00	4.25	0.425	2.12
49.	*Galium asperuloides* Edgew	0.78	12.50	6.20	0.496	3.26
50.	*Gentiana ornate* G.Don Griseb	0.08	2.50	3.00	1.200	0.55
51.	*Gentiana tubiflora* G.Don. Griseb	0.18	10.00	1.75	0.175	1.51
52.	*Geranium pratense* Linn.	0.53	17.50	3.00	0.171	3.37
53.	*Heracleum candicans* Wall. Ex. DC.	1.38	62.50	2.20	0.035	33.11
54.	*Hippophae rhamnoides* Linn.	0.20	10.00	2.00	0.200	1.81
55.	*Hyoscyamus niger* Linn.	0.10	2.50	4.00	1.600	1.02
56.	*Hyssopus officinalis* Linn.	2.25	22.50	10.00	0.444	9.57
57.	*Lactuca dissecta* D.Don	0.55	17.50	3.14	0.180	3.26
58.	*Leontopodium jacotianum* P. Beauv	0.20	7.50	2.67	0.356	1.37

59.	*Lomatogonium carinthiacum* (Wulfen) Reichb	0.23	10.00	2.25	0.225	1.89
60.	*Lotus corniculata* Linn.	0.28	7.50	3.67	0.489	1.55
61.	*Malva rotundifolia* Linn.	0.48	10.00	4.75	0.475	2.54
62.	*Medicago falcata* Linn.	0.10	2.50	4.00	1.600	0.55
63.	*Melilotus alba* Med. ex. Desr.	1.28	27.50	4.64	0.169	6.55
64.	*Mentha longiflolia* (L.) Hud.	3.93	40.00	9.81	0.245	17.79
65.	*Nepeta erecta* Royle ex.Benth	1.00	20.00	5.00	0.250	5.02
66.	*Nepeta podostachys* Benth.	0.13	7.50	1.67	0.222	1.21
67.	*Oxyria digyna* (L.) Hill.	0.88	17.50	5.00	0.286	4.28
68.	*Phlomis bracteosa* Royle ex. Benth	0.18	10.00	1.75	0.175	1.84
69.	*Pimpinella diversifolia* DC.	0.10	2.50	4.00	1.600	0.56
70.	*Plantago lanceolata* Linn.	1.00	27.50	3.64	0.132	5.91
71.	*Polygonum polystachya* Wall. ex.Lehm.	0.48	10.00	4.75	0.475	6.66
72.	*Potentilla argyrophylla* Wall. ex Lehm.	0.10	2.50	4.00	1.600	0.71
73.	*Primula denticulata* Smith	0.20	7.50	2.67	0.356	1.49
74.	*Ranunculus laetus* Wall. .ex. D. Don	0.20	10.00	2.00	0.200	1.59
75.	*Rheum webbiana* Royle	0.05	2.50	2.00	0.800	1.15
76.	*Rubia cordifolia* Hook. f.	0.03	2.50	1.00	0.400	0.35
77.	*Rumex nepalensis* Sprengel	0.48	22.50	2.11	0.094	12.05
78.	*Salix alba* Linn.	0.05	2.50	2.00	0.800	0.49
79.	*Salvia glutinosa* FBI	0.23	7.50	3.00	0.400	1.87
80.	*Saussurea albescens* Hook. f. ex. Thoms. ex. Clarke	0.93	10.00	9.25	0.925	3.96
81.	*Scorzonera virgata* DC.	0.25	12.50	2.00	0.160	2.01
82.	*Senecio chrysanthemoides* DC.	1.00	20.00	5.00	0.250	5.07
83.	*Sibbaldia parviflora* Edgew	0.25	2.50	10.00	4.000	0.96
84.	*Silene viscosa* (L.) Pers.	0.30	10.00	3.00	0.300	1.87
85.	*Taraxacum officinale* Wigg.	0.38	22.50	1.67	0.074	3.39
86.	*Thallictrum cultratum* Wallich	1.00	37.50	2.67	0.071	7.59
87.	*Thymus linearis* Benth ex. Benth	0.30	2.50	12.00	4.800	0.99
88.	*Urtica dioica* Linn.	0.98	10.00	9.75	0.975	4.63
89.	*Verbascum thapsus* Linn.	0.30	27.50	1.09	0.040	6.78

The value of abundance was maximum for *Ephedra gerardiana* followed by *Anemone rivularis*, *Thymus linearis* and *Arenaria festucoides. Heracleum candicans* recorded highest value of IVI (33.11) followed by *Ephedra gerardiana* (19.72), *Mentha longifolia* (17.79) and *Rumex nepalensis* (12.05). The ratio of abundance to frequency indicates that distribution pattern of all species except *Heracleum candicans* and *Verbascum thapsus* was contiguous.

At 3800-4200m elevation, total number of shrub species was 5 (Table 4). *Caragyna brevispina* was dominant species followed by *Astragalus rhizanthus* with respect to density and abundance. On the basis of IVI, *Cotoneaster microphyllus* recorded highest value (100.50) followed by *Caragyna brevispina* (78.94), *Astragalus rhizanthus* (53.70) and *Lonicera spinosa* (37.22). The distribution pattern of all the species was contiguous.

The number of herb species was 63 (Table 5) at elevation of 3800-4200m and *Arenaria griffithii* was dominant species followed by *Bergenia stracheyi*, *Anemone obtusiloba* and *Gentiana ornata* with respect to density. The value of abundance was maximum for *Arenaria griffithii* followed by *Bergenia stracheyi*, *Gentiana ornata* and *Anemone obtusiloba. Bergenia stracheyi* recorded highest value of IVI (50.34) followed by *Anemone obtusiloba* (26.39), *Arenaria griffithii* (23.57) and *Anaphalis*

contorta (15.17). The distribution pattern of all species except *Meconopsis acuneata* was contiguous.

At elevation 4200-4600m, total number of shrub species was 3 (Table 6). *Juniperus indica* was dominant species followed by *Lonicera spinosa* and *Rhododendron anthopogon* in term of density, frequency and abundance. *Juniperus indica* recorded highest value of IVI (190.27) followed by *Rhododendron anthopogon* (62.08) and *Lonicera spinosa* (47.66). The distribution pattern of all the species was contiguous.

In case of herbs, total number of species was 36 (Table 7) with the dominance of *Bistorta affinis* followed by *Bergenia stracheyi, Arenaria festucoides* and *Potentilla parviflora* in term of density. The value of frequency was maximum for *Potentilla parviflora* followed by *Bistorta affinis* and *Bergenia stracheyi* where as the value of abundance was maximum for *Thymus linears* followed by *Arenaria festucoides*, *Androsace sarmentosa* and *Bergenia stracheyi*. The distribution pattern of all the species except *Rheum webbianum* was contiguous.

At elevation 4600-5000m, total number of species was 2 (Table 8) with the dominance of *Rhododendron anthopogon* followed by *Juniperus indica* in term of density, frequency, abundance and IVI. The distribution pattern of both the species was contiguous.

Table 4: Distribution of shrub species in Hango valley of district Kinnaur at 3800-4200m elevation.

S. No.	Species	Density (ha^{-1})	Frequency (%)	Abundance	A/F	IVI
1.	*Astralagus rhizanthus* Royle ex. Benth	3888.89	30.00	11.67	0.389	53.70
2.	*Caragana brevispina* Royle	6111.11	30.00	18.33	0.611	78.94
3.	*Cotoneaster microphyllus* Wall. ex. Lindley	3333.33	40.00	7.50	0.188	100.50
4.	*Lonicera spinosa* Jacq.	2333.33	20.00	10.50	0.525	37.22
5.	*Rosa webbiana* Wall. ex. Royle	1666.67	20.00	7.50	0.375	29.64

Table 5: Distribution of herb species in Hango valley of district Kinnaur at 3800-4200m elevation.

S. No.	Species	Density (m^{-2})	Frequency (%)	Abundance	A/F	IVI
1.	*Aconitum violaceum* Jacq. ex. Stapf.	0.20	10.00	2.00	0.200	1.80
2.	*Anaphalis contorta* (D.Don) Hook. f.	3.03	35.00	8.64	0.247	14.17
3.	*Anaphalis triplinervis* (Sims) C.B.Clarke	0.43	10.00	4.25	0.425	2.49
4.	*Androsace sarmentosa*Wall.	0.25	15.00	1.67	0.111	2.61
5.	*Anemone obtusiloba* D.Don	4.08	37.50	10.87	0.290	25.39
6.	*Aquilegia fragrans* Benth.B G.Goteborg	0.30	5.00	6.00	1.200	1.71
7.	*Arenaria griffithii* Boiss	6.88	52.50	13.10	0.249	22.57
8.	*Arenaria serpyllifolia* Linn.	1.20	12.50	9.60	0.768	4.29
9.	*Arenebia euchroma* Royle ex. Benth I.M.Johnston	0.50	12.50	4.00	0.320	4.59
10.	*Arnebia guttata* Bunge.	0.60	7.50	8.00	1.067	3.63
11.	*Aster flaccidus* Bunge	0.23	10.00	2.25	0.225	1.82
12.	*Astralagus rhizanthus* Royle ex. Benth	0.88	20.00	4.38	0.219	8.85
13.	*Bergenia stracheyi* (Hook.f.& Thoms) Engl.	4.55	37.50	12.13	0.324	49.34
14.	*Bistorta affinis* (D.Don) Greene	0.25	12.50	2.00	0.160	2.35
15.	*Campanula latiflolia* Linn.	0.18	7.50	2.33	0.311	1.33
16.	*Chenopodium foliolosum* (Moench) Asch	0.20	10.00	2.00	0.200	2.23
17.	*Cirsium wallichi* DC.	0.15	5.00	3.00	0.600	1.97
18.	*Convolvulus arvensis* Linn.	0.23	5.00	4.50	0.900	1.33

19.	*Conyza stricta* Willd.	0.28	10.00	2.75	0.275	1.99
20.	*Corydalis crassissima* Camb.	0.43	7.50	5.67	0.756	
21.	*Cynoglossum furcatum* Wall ex. Roxb.	0.10	2.50	4.00	1.600	0.58
22.	*Delphinium viscosum* Hook. f.& Thom.	0.58	10.00	5.75	0.575	4.44
23.	*Dianthus angulatus* Royle	0.28	5.00	5.50	1.100	1.95
24.	*Ephedra gerardiana* Wall. ex.Stapf.	0.13	10.00	1.25	0.125	3.45
25.	*Epilobium latifolium* Linn.	0.03	2.50	1.00	0.400	0.39
26.	*Epilobium laxum* Royle	0.40	10.00	4.00	0.400	2.55
27.	*Euphorbia stracheyi* Boiss	0.55	10.00	5.50	0.550	2.98
28.	*Ferula jaeschkeana* Vatke	0.28	12.50	2.20	0.176	3.12
29.	*Galium asperuloides* Edgew	0.28	7.50	3.67	0.489	1.55
30.	*Galium verum* Linn.	0.48	10.00	4.75	0.475	2.28
31.	*Gentiana ornate* (G.Don.) Griseb	3.60	30.00	12.00	0.400	13.47
32.	*Gentiana tubiflora* (G.Don) Griseb	0.13	7.50	1.67	0.222	1.28
33.	*Gentinella moorcroftiana* Wall. ex. G. Don	0.30	10.00	3.00	0.300	1.91
34.	*Geranium pretense* Linn.	2.48	60.00	4.13	0.069	13.08
35.	*Hyssopus officinalis* Linn.	0.63	12.50	5.00	0.400	3.16
36.	*Lactuca longifolia* DC.	0.05	2.50	2.00	0.800	0.48
37.	*Leontopodium jacotianum* P. Beauv.	0.13	5.00	2.50	0.500	1.05
38.	*Lomatogonium carinthiacum* (Wulfen) Reichb.	0.10	7.50	1.33	0.178	1.21
39.	*Meconopsis acuneata* Royle	0.15	32.50	0.46	0.014	4.65
40.	*Melilotus alba* Med.ex.Desr.	0.10	2.50	4.00	1.600	0.59
41.	*Nepeta erecta* Royle ex. Benth	0.80	22.50	3.56	0.158	5.03
42.	*Orobanche alba* Stephen ex. Willd.	1.50	7.50	20.00	2.667	11.02
43.	*Oxyria digyna* (L.) Hill.	0.05	2.50	2.00	0.800	0.44
44.	*Oxytropis lapponica* (Wahlemb) Gay	0.45	15.00	3.00	0.200	3.20
45.	*Parnessia nubicola* Wallich ex. Royle	0.48	7.50	6.33	0.844	2.18
46.	*Pedicularis longifolia* Rudolph	0.15	5.00	3.00	0.600	1.29
47.	*Plantago tibetica* Hook f.& Thomas	0.45	12.50	3.60	0.288	2.92
48.	*Pleurospermum candollei* (DC) C. B. Clarke	0.15	10.00	1.50	0.150	2.11
49.	*Polygonum polystachya* Wall ex. Lehm	0.65	22.50	2.89	0.128	11.35
50.	*Potentilla parviflora* Willd.	0.90	30.00	3.00	0.100	8.22
51.	*Ranunculus hirtellus* Royle ex.D.Don	0.15	7.50	2.00	0.267	1.30
52.	*Rheum webbianum* Royle	0.10	5.00	2.00	0.400	2.63
53.	*Rhodiola heterodonta* Hook f. & Thoms.	0.25	7.50	3.33	0.444	2.01
54.	*Salvia nubicola* SW.	0.55	7.50	7.33	0.978	3.53
55.	*Saxifraga mucronulata* Royle	0.33	10.00	3.25	0.325	2.11
56.	*Sedum ewersii* Ledeb.	0.08	5.00	1.50	0.300	0.83

57.	*Sibbaldia parviflora* Edgew	0.25	12.50	2.00	0.160	2.54
58.	*Tanacetum tibeticum* Hook f. Thoms ex. C.B.Clarke	0.40	15.00	2.67	0.178	3.07
59.	*Taraxacum officinale* Wigg.	0.20	10.00	2.00	0.200	1.75
60.	*Thymus linearis* Benth ex. Benth	0.40	20.00	2.00	0.100	3.34
61.	*Trifolium minus* Linn.	0.50	10.00	5.00	0.500	2.50
62.	*Urtica dioica* Linn.	0.30	5.00	6.00	1.200	3.39
63.	*Verbascum thapsus* Linn.	0.08	7.50	1.00	0.133	2.01

Table 6: Distribution of shrub species in Hango valley of district Kinnaur at 4200-4600m elevation.

S. No.	Species	Density (ha^{-1})	Frequ-ency (%)	Abund ance	A/F	IVI
1.	*Juniperus indica* Bertol	6666.67	66.67	9.00	0.135	190.27
2.	*Rhododendron anthopogon* D.Don	1481.48	33.33	4.00	0.120	62.08
3.	*Lonicera spinosa* Jacq.	1851.85	33.33	5.00	0.150	47.66

Table 7: Distribution of herbs species in Hango valley of district Kinnaur at 4200- 4600m elevation.

S. No.	Species	Density (m^{-2})	Frequ-ency (%)	Abund ance	A/F	IVI
1.	*Aconogonum tortuosum* D. Don. Hara	0.40	5.00	8.00	1.600	2.02
2.	*Anaphalis triplinervis* (Sims) C. B.Clarke	1.05	15.00	7.00	0.467	4.68
3.	*Anaphalis contorta* (D.Don) Hook. f.	2.90	45.00	6.44	0.143	14.00
4.	*Androsace mucronifolia* Watt.& Eremurus	1.40	25.00	5.60	0.224	6.89
5.	*Androsace sarmentosa* Wall.	1.15	10.00	11.50	1.150	4.84
6.	*Arenaria festucoides* Benth	3.75	30.00	12.50	0.417	12.88
7.	*Bergenia stracheyi* (Hook f. & Thoms) Engl.	4.85	45.00	10.78	0.240	50.39
8.	*Bistorta affinis* (D.Don.)Greene	4.90	50.00	9.80	0.196	19.04
9.	*Cassiope fastigiata* Wall. (D. Don.)	0.90	10.00	9.00	0.900	4.51
10.	*Delphinium brunonianum* Royle	0.85	20.00	4.25	0.213	7.38
11.	*Delphinium viscosum* Hook.&Thom.	0.45	20.00	2.25	0.113	4.92
12.	*Ephedra gerardiana* Wall. ex. Stapf.	0.20	5.00	4.00	0.800	4.18
13.	*Gentiana tubiflora* (G.Don.) Griseb	0.70	15.00	4.67	0.311	4.45
14.	*Gentinella moorcroftiana* Wall ex G.Don	0.15	5.00	3.00	0.600	1.02
15.	*Geranium pretense* Linn.	0.35	10.00	3.50	0.350	2.34
16.	*Lactuca macrorhiza* Royle Hook. f.	0.10	5.00	2.00	0.400	0.92
17.	*Lomatogonium carinthianum* (Wulfen) Reichb	0.30	12.50	2.40	0.192	2.47
18.	*Oxyria digyna* (L.) Hill.	0.35	10.00	3.50	0.350	2.29
19.	*Phlomis bracteosa* Royle ex. Benth	0.40	22.50	1.78	0.079	4.94
20.	*Pleurospermum candollei* (DC.) C. B.Clarke	0.15	15.00	1.00	0.067	2.86
21.	*Polygonum polystachya* Wall ex. Meissn	1.20	40.00	3.00	0.075	21.22
22.	*Potentilla parviflora* Willd.	3.30	75.00	4.40	0.059	18.34

23.	*Primula denticulata* Smith.	1.20	25.00	4.80	0.192	7.54
24.	*Rheum webbiana* Royle	0.40	35.00	1.14	0.033	12.53
25.	*Rhodiola heterodonta* Hook f.& Thomson	0.50	15.00	3.33	0.222	4.19
26.	*Salix alba* Linn.	0.70	10.00	7.00	0.700	4.66
27.	*Saussurea roylea* (DC.) Sch. Bip.	1.90	40.00	4.75	0.119	13.91
28.	*Saussurea graminifolia* Wall ex DC.	0.25	12.50	2.00	0.160	3.20
29.	*Saxifraga stenophylla* Royle	0.20	5.00	4.00	0.800	1.35
30.	*Sedum ewersii* Ledeb	0.10	5.00	2.00	0.400	0.97
31.	*Selinum tenuifolium* Wall ex. C. B. Clarke	0.70	15.00	4.67	0.311	8.38
32.	*Sibbaldia parviflora* Edgew	0.95	20.00	4.75	0.238	5.27
33.	*Tanacetum tibetica* Hook f. Thomas ex. C.B.Clarke	0.90	25.00	3.60	0.144	6.15
34.	*Thymus linearis* Benth ex. Benth	2.90	20.00	14.50	0.725	9.55
35.	*Verbascum thapsus* Linn.	0.50	17.50	2.86	0.163	13.76
36.	*Waldheimia glabra* (Decne) Regel	1.85	20.00	9.25	0.463	9.66

Table 8: Distribution of shrubs species in Hango valley of district Kinnaur at 4600-5000m elevation.

S. No.	Species	Density (ha^{-1})	Frequ-ency (%)	Abun-dance	A/F	IVI
1.	*Juniperus indica* Bertol	5925.93	66.67	8.00	0.120	91.54
2	*Rhododendron anthopogon* D.Don	16666.67	93.33	16.07	0.172	208.46

Among the 30 species of herbs (Table 9), *Anaphalis contorta* was dominance species having maximum density and frequency. This was followed by *Thymus linearis*, *Arenaria festucoides* and *Saussurea roylea* in term of density. The value of abundance was maximum for *Saussurea roylea* followed by *Selinum tenuifolium*, *Arenaria festucoides* and *Sedum ewersii*. *Bergenia stracheyi* recorded maximum value of IVI (42.90), followed by *Selinum tenuifolium* (22.56), *Anaphalis contorta* (19.09) and *Thymus linearis* (16.29). The distribution pattern of all the species except *Androsace sarmentosa* and *Potentilla argyrophylla* was contiguous.

Table 9: Distribution of herbs species in Hango valley of district Kinnaur at 4600-5000m elevation.

S. No.	Species	Density (m^{-2})	Frequ-ency (%)	Abun-dance	A/F	IVI
1.	*Anaphalis contorta* (D.Don.) Hook.f.	4.40	67.50	6.52	0.097	19.09
2.	*Anaphalis triplinervis* (Sims.) C. B.Clarke	0.88	20.00	4.38	0.219	4.57
3.	*Androsace sarmentosa* Wall.	0.83	47.50	1.74	0.037	8.69
4.	*Arenaria festucoides* Benth	3.25	32.50	10.00	0.308	11.59
5.	*Bergenia stracheyi* Hook f. Thoms. Engl.	2.13	30.00	7.08	0.236	42.90
6.	*Bistorta affinis* (D.Don.) Greene	2.60	35.00	7.43	0.212	10.62
7.	*Corydalis govaniana* Wall.	1.30	27.50	4.73	0.172	6.79
8.	*Cremanthodium ellisii* Benth	0.15	5.00	3.00	0.600	1.18
9.	*Delphinium brunonianum* Royle	0.95	20.00	4.75	0.238	8.38
10.	*Delphinium viscosum* Hook .f. &.Thom.	1.15	32.50	3.54	0.109	10.52
11.	*Epilobium lotifolium* Linn.	1.83	45.00	4.06	0.090	11.31
12.	*Gentiana tubiflora* (G.Don.) Griseb	0.93	25.00	3.70	0.148	6.26
13.	*Meconopsis acuneata* Royle	0.25	12.50	2.00	0.160	2.67
14.	*Oxyria digyna* (L.) Hill.	1.90	37.50	5.07	0.135	9.23

15.	*Polygonum polystachya* Wall.ex Lehm.	0.53	17.50	3.00	0.171	8.49
16.	*Potentilla argyrophylla* Wall. ex. Lehm.	1.35	62.50	2.16	0.035	14.10
17.	*Potentilla parviflora* Willd.	1.83	50.00	3.65	0.073	10.51
18.	*Primula denticulata* Smith	0.65	22.50	2.89	0.128	4.88
19.	*Rhodiola heterodonta* Hook f. Thomson	0.85	25.00	3.40	0.136	6.57
20.	*Salvia nubicola* SW.	0.88	22.50	3.89	0.173	6.22
21.	*Saussurea obovallata* (DC.) Edgew	0.75	10.00	7.50	0.750	10.05
22.	*Saussurea roylea* (DC.) Sch. Bip.	2.80	17.50	16.00	0.914	12.76
23.	*Saussurea gossypiphora* D. Don.	0.30	20.00	1.50	0.075	5.15
24.	*Saxifraga stenophylla* Royle	0.70	17.50	4.00	0.229	4.37
25.	*Sedum ewersii* Ledeb	1.23	15.00	8.17	0.544	5.49
26.	*Selinum tenuifolium* Wall ex C.B.Clarke	2.45	22.50	10.89	0.484	22.56
27.	*Stellaria media* Linn.	0.88	17.50	5.00	0.286	4.37
28.	*Tanacetum tibeticum* Hook f. Thoms ex.C.B.Clarke	0.70	17.50	4.00	0.229	7.20
29.	*Thymus linearis* Benth ex Benth	4.18	55.00	7.59	0.138	16.29
30.	*Waldheimia glabra* (Decne) Regel	1.40	17.50	8.00	0.457	7.18

In the present study tree cover was observed only at low elevation whereas shrub sratum was observed at all the elevation ranges. The number of shrub and herb species was more at low elevation as compared to higher elevational ranges.The value of concentration of dominance (C), index of diversity (H), richness index (R) and evenness index (E) for trees, shrubs and herbs at different altitudes was given in Table 10. The higher the value of concentration of dominance, the greater is the homogenous nature of the community and vice- versa (Kohli *et al*., 2004). The lower value of dominance shows that dominance of plants is shared by many species. The diversity indices and richness index was more in lower elevation indicating higher diversity of the species. The species diversity is regulated by long term factors like community stability and evolutionary time as heterogeneity of both macro and micro environment affects the diversification among different communities. The higher values of index of diversity indicate the variability in the type of species and heterogeneity in the communities, whereas, the lesser values point to the homogeneity in the community. The evenness index was comparatively more in lower altitudinal ranges than higher altitudinal ranges indicating that species are evenly distributed in lower elevations.

Table 10: Concentration of Dominance (C), Diversity index (H), Richness index (R) and Evenness index (E) for trees, shrubs and herbs at different elevations in Hango valley of district Kinnaur.

Altitude	Plant Category	Concentration of Dominance (C)	Diversity Index (H)	Richness Index (R)	Evenness Index (E)
3400-3800m	Tree	0.447	0.879	0.45	0.80
	Shrub	0.161	1.958	1.25	0.89
	Herb	0.033	3.817	9.69	0.89
3800-4200m	Shrub	0.238	1.513	0.65	0.94
	Herb	0.054	3.505	8.28	0.85
4200-4600m	Shrub	0.470	0.907	0.36	0.83
	Herb	0.058	3.203	4.69	0.89
4600-5000m	Shrub	0.575	0.615	0.16	0.88
	Herb	0.052	3.181	3.88	0.93

Table 11: Index of similarity and dissimilarity for herb species at different altitudes in Hango valley of district Kinnaur.

Altitudes	3800-4200m	4200-4600m	4600-5000m
3400-3800m	0.43 (0.57)	0.29(0.71)	0.19(0.81)
3800-4200m	-	0.44(0.56)	0.34(0.66)
4200-4600m		-	0.64(0.36)

Note: Values in parenthesis are index of dissimilarity.

Index of similarity for shrubs between 3400-3800m and 3800-4200m, between 3400-3800m and 4200-4600m, between 3400-3800m and 4600-5000m, between 3800-4200mm and 4200-4600mm, between 3800-4200m and 4600-5000m and between 4200-4600m and 4600-5000m was 0.57, 0.17, 0.0, 0.25, 0.0 and 0.80 respectively whereas, index of dissimilarity for the same was 0.43, 0.83, 1.0, 0.75, 1.0 and 0.20 respectively. This indicating less similarity of species between these elevations. Index of similarity for herb species between different altitudes was low as given in Table 11. This indicating more dissimilarity of species between different altitudes. The nature of plant community at a place is determined by the species that grow and develop in such environment. The differences in the species composition from altitude to altitude is mostly due to micro environment changes (Mishra *et al;* 1997).

Plants of Medicinal Value: The important plants of medicinal value found in the Hango valley of cold desert area in Kinnaur district were compiled following Chopra *et al* (1956), Kirtikar and Basu (1987) and Kala (2002). These include, *Aconitum violaceum, Aconogonum tortuosum, Anaphalis triplinervis, Anemone obtusiloba, Aster flaccidus, Astragalus rizanthus, Arnebia euchroma, Arnebia guttata, Cannabis sativa, Capparis spinosa, Clematis oriantalis, Bistorta affinis, Bergenia stracheyi, Bupleurum falcatum, Cassiope fastigiata, Chenopodium album, Chenopodium foliosum, Corydalis govaniana, Dactylorhiza hatagirea, Delphinium brunonianum, Ephedra gerardiana, Echinops cornigerus, Erigeron alpinus, Euphorbia stracheyi, Ferula jaeschkeana, Galium aparine, Gentinella moorcrogtiana, Plantago tibetica, Hippophae rhamnoides, Hyoscyamus niger, Hyssopus officinalis, Juniperus polycapos, Lactuca dissecta, Lactuca macrorhiza, Meconopsis aculeata, Mentha longifolia, Nepeta erecta, Nepeta podostachys, Oxyria digyna, Oxytropis laponica, Phlomis bracteosa, Pleurospermum candollei, Polygonum polystachya, Potentilla argyrophylla, Primula denticulata, Plantago lanceolata, Ranunculus laetus, Ranunculus hirtellus, Rheum webbianum, Rhodiola heterodonta, Rhododendron anthopogon, Rosa webbiana, Rumex nepalensis, Saussurea obvallata, Saussurea gossypiphora, Sedum ewersii, Selinum tenuifolium, Taraxacum officinale, Thymus linearis, Urtica dioica, Verbascum thapsus* and *Waldheimia glabra.*

Threatened Plants: Out of 62 medicinal plant species recorded from the area, 18 species i.e. *Aconitum violaceum, Arnebia euchroma, Bergenia stracheyi, Dactylorhiza hatagirea, Ephedra gerardiana, Ferula jaschkeana, Hippophae rhamnoides, Hyoscyamus niger, Hyssopus officinalis, Juniperus polycarpos, Meconopsis aculeata, Pleurospermum candollei, Rheum webbianum, Rhodiola heterodonta, Rhododendron anthopogon, Rhododendron campanulatum, Saussurea obvallata* and *Saussurea gossypiphora* fall in the category of threatened plants when compared with the available literature like Red Data Book and CAMP Report (Ved *et al*, 2003).

The habitat of most of the plant species have shrunk due to expansion of human population and environmental degradation primarily due to heavy live stock grazing, uncontrolled and unscientific harvest of species, unregulated tourism and construction of roads etc. The better conservation of natural resources can be done by inclusion of a section on the plant conservation especially of rare and endangered medicinal plants in the wild life protection act, promotion of community based conservation, *in-situ* conservation through the establishment of nature reserves, *ex-situ* conservation through tissue culture, developing cultivation technologies and nurseries of medicinal plants and conducting of regular training on the procedure of medicinal plants collection, processing among the local people, traders and real stake holders.

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